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PATENT COOPERATION TREATY

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NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

MAUCHER, BÖRJES & KOLLEGEN
Dreikönigstrasse 13
79102 Freiburg
ALLEMAGNE

Date of mailing (day/month/year) 16 November 2001 (16.11.01)	
Applicant's or agent's file reference PC 00 091 K	IMPORTANT NOTIFICATION
International application No. PCT/EP00/02001	International filing date (day/month/year) 08 March 2000 (08.03.00)

1. The following indications appeared on record concerning: <input type="checkbox"/> the applicant <input type="checkbox"/> the inventor <input checked="" type="checkbox"/> the agent <input type="checkbox"/> the common representative		
Name and Address SCHMITT, Hans Maucher, Börjes & Kollegen Dreikönigstrasse 13 D-79102 Freiburg Germany	State of Nationality	State of Residence
	Telephone No. 49 761 79 174 0	RECEIVED DEC 11 2001 TECHNOLOGY CENTER
	Facsimile No. 49 761 79 174 30	
	Teleprinter No.	
2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning: <input checked="" type="checkbox"/> the person <input type="checkbox"/> the name <input type="checkbox"/> the address <input type="checkbox"/> the nationality <input type="checkbox"/> the residence		
Name and Address MAUCHER, BÖRJES & KOLLEGEN Dreikönigstrasse 13 79102 Freiburg Germany	State of Nationality	State of Residence
	Telephone No. 49 761 79 174 0	
	Facsimile No. 49 761 79 174 30	
	Teleprinter No.	
3. Further observations, if necessary:		
4. A copy of this notification has been sent to: <div style="display: flex; justify-content: space-between;"> <div> <input checked="" type="checkbox"/> the receiving Office <input type="checkbox"/> the International Searching Authority <input type="checkbox"/> the International Preliminary Examining Authority </div> <div> <input type="checkbox"/> the designated Offices concerned <input checked="" type="checkbox"/> the elected Offices concerned <input type="checkbox"/> other: </div> </div>		

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Céline Faust Telephone No.: (41-22) 338.83.38
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PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents
 United States Patent and Trademark
 Office
 Box PCT
 Washington, D.C.20231
 ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 20 October 2000 (20.10.00)	
International application No. PCT/EP00/02001	Applicant's or agent's file reference PC 00 091 K
International filing date (day/month/year) 08 March 2000 (08.03.00)	Priority date (day/month/year) 17 March 1999 (17.03.99)
Applicant REUTER, Karl	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
 27 September 2000 (27.09.00)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Manu Berrod Telephone No.: (41-22) 338.83.38
--	---

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PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference PC 00 091 K	FOR FURTHER ACTION		See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/EP00/02001	International filing date (<i>day/month/year</i>) 08/03/2000	Priority date (<i>day/month/year</i>) 17/03/1999	
International Patent Classification (IPC) or national classification and IPC B01D9/00			
Applicant REUTER CHEMISCHE APPARATEBAU KG et al.			

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 27/09/2000	Date of completion of this report 07.06.2001
Name and mailing address of the international preliminary examining authority: <div style="display: flex; align-items: center;"> <div> European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465 </div> </div>	Authorized officer Persichini, C Telephone No. +49 89 2399 8617



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/02001

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-5 as originally filed

Claims, No.:

1-10 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
 - ☐ the language of publication of the international application (under Rule 48.3(b)).
 - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).
3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:
- ☐ contained in the international application in written form.
 - ☐ filed together with the international application in computer readable form.
 - ☐ furnished subsequently to this Authority in written form.
 - ☐ furnished subsequently to this Authority in computer readable form.
 - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
 - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.
4. The amendments have resulted in the cancellation of:
- ☐ the description, pages:
 - ☐ the claims, Nos.:
 - ☐ the drawings, sheets:
5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/02001

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	
	No:	Claims	1-6, 8-10
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-10
Industrial applicability (IA)	Yes:	Claims	1-10
	No:	Claims	

2. Citations and explanations see separate sheet

- (1) WO-A-97 32 644
- (2) US-A-3 141 743

Re Item V

1. Document (1) discloses a process for purifying an impure substance (see (1), page 2, lines 19, 20 in context with page 3, lines 28, 29) through emulsion crystallisation (1), page 2, lines 21 to 25 in context with page 3, line 1) comprising the steps of
 - (a) forming an emulsion of organic liquid droplets in a continuous water phase, which emulsion contains the impure substance ((1), eg page 3, lines 31, 32 in context with page 5, lines 11 ff, page 5, line 4, page 9, lines 1 to 3 and page 14, lines 13 to 23);
 - (b) super-saturating the emulsion in the substance ((1), eg page 14, line 20, 21 or page 16, lines 8 to 11);
 - (c) inducing crystallization of the substance, whereby crystallization takes place in the water phase ((1), page 9, line 30 to page 10, line 4 in context with page 2, lines 27 to 29 and page 5, line 4);
 - (d) isolating the crystals of the substance from the emulsion, yielding an emulsion-filtrate ((1), eg page 14, lines 1 to 3, page 16, lines 25 to 27 or page 17, lines 6 to 17);
 - (e) dissolving additional impure substance in the emulsion-filtrate (page 16, lines 26 to 31 in context with page 15, lines 26 to 32); and
 - (f) repeating steps (b)- (d) with the emulsion obtained from step (e) ((1), page 16, line 33 to page 17, line 5)

Consequently, no difference between the subject-matter defined by claim 1 and the process disclosed in document (1) can be seen. Therefore, the subject-matter of claim 1 is not new and claim 1 does not meet the requirements of Art. 33(2) PCT.

2. In the light of documents (1) and (2) the features of the dependent claims appear to be either known or evident. Thus the dependent claims do also not meet the requirements of Art. 33(2) and (3) PCT.

PATENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference PC 00 091 K	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/EP 00/ 02001	International filing date (day/month/year) 08/03/2000	(Earliest) Priority Date (day/month/year) 17/03/1999
Applicant REUTER CHEMISCHE APPARATEBAU KG et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

☒ None of the figures.

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

A method for purifying substances through emulsion crystallisation is described, whereby (a) an emulsion of organic liquid droplets in a continuous water phase containing the impure substance is formed; (b) the emulsion is super-saturated in the substance; (c) crystallisation of the substance in the water phase is induced; (d) the crystals of the substance are isolated from the emulsion, yielding an emulsion-filtrate; (e) additional impure substance is dissolved in the emulsion-filtrate; and (f) steps (b)-(d) are repeated with the emulsion obtained from step (e).

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/02001

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 32644 A (REUTER CHEMISCHE APPARATEBAU ;REUTER KARL (DE)) 12 September 1997 (1997-09-12) cited in the application page 2, line 19 -page 5, line 8	1-6, 8-10
Y	page 15, line 1 -page 17, line 22 ---	7
Y	US 3 141 743 A (THE NORTH AMERICAN COAL CORPORATION) 21 July 1964 (1964-07-21) column 4, line 48 -column 6, line 18 -----	7

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

8 May 2000

Date of mailing of the international search report

15/05/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Persichini, C

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 00/02001

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9732644	A	12-09-1997	EP	0956122 A	17-11-1999
US 3141743	A	21-07-1964	FR	1330983 A	16-12-1963
			GB	1013984 A	
			NL	280232 A	

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : B01D 9/00	A1	(11) International Publication Number: WO 00/54865 (43) International Publication Date: 21 September 2000 (21.09.00)
(21) International Application Number: PCT/EP00/02001 (22) International Filing Date: 8 March 2000 (08.03.00) (30) Priority Data: 99200820.1 17 March 1999 (17.03.99) EP (71) Applicant (for all designated States except US): REUTER CHEMISCHE APPARATEBAU KG [DE/DE]; Engesserstr. 4b, D-79108 Freiburg (DE). (72) Inventor; and (75) Inventor/Applicant (for US only): REUTER, Karl [DE/DE]; Talstrasse 1, D-79102 Freiburg (DE). (74) Agents: SCHMITT, Hans et al.; Dreikönigstrasse 13, D-79102 Freiburg (DE).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>
(54) Title: EMULSION CRYSTALLISATION WITH RECYCLE (57) Abstract A method for purifying substances through emulsion crystallisation is described, whereby (a) an emulsion of organic liquid droplets in a continuous water phase containing the impure substance is formed; (b) the emulsion is super-saturated in the substance; (c) crystallisation of the substance in the water phase is induced; (d) the crystals of the substance are isolated from the emulsion, yielding an emulsion-filtrate; (e) additional impure substance is dissolved in the emulsion-filtrate; and (f) steps (b)-(d) are repeated with the emulsion obtained from step (e).		

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Emulsion Crystallisation with Recycle

Background of the Invention

5 The present invention relates to a process for purifying an impure substance through emulsion crystallisation. In particular, the present invention enables the preparation of highly purified crystalline materials at high yields.

10 Crystallisation of substances from emulsions is well known. C.f. EP 0 548 028 A1 and WO 97/32644, both belonging to the inventor of the present invention. In such emulsion crystallisation processes, an emulsion is formed of organic liquid droplets in a continuous water phase. Then, a mixture of substances is dissolved in the emulsion, and the emulsion is supersaturated in the desired substance of the mixture. The desired substance is then allowed to crystallise in the water phase, optionally with the aid of seed crystals.

15

The present invention builds upon this technology to enable ultra-high purification of substances at high yields. As such, the present invention vastly increases the commercial potential of emulsion crystallisation processes.

20 The aforementioned patent publications describe emulsion crystallisation processes for purifying substances which optionally can be carried out continuously. In these processes, crystals that are formed are filtered off from the emulsion, and the resulting emulsion-filtrate is heated. The heated emulsion-filtrate is then contacted with impure substance in a column that is kept separate from the vessel in which crystallisation takes place. This serves to re-
25 load the emulsion-filtrate with impure substance, which is then filtered and cooled and re-introduced into the crystallisation vessel.

Carrying out emulsion crystallisation continuously, as described in these patent publications, can lead to some difficulties. The equipment it requires is somewhat complicated, requiring
30 the external column, two filters and two heat exchange units. The external column and the filters are susceptible to clogging. The process risks losing emulsion during the removal of undissolved leftover crude materials in the column, which will reduce its efficiency. Re-loading of impure substance in the external column occurs without the benefit of stirring, which also reduces its efficiency.

35

Another disadvantage of some emulsion crystallisation processes is that their yields following a single crystallisation step can be substantially lower than the corresponding yields obtained

by classical crystallisation due to difficulty in removing solvents from the mother liquor. Or the emulsion cannot be highly loaded with impure substance as this would lead to emulsion instability, unworkable viscosity and/or sub-optimal growth conditions for the crystals.

5 Summary of the invention

The present invention overcomes the disadvantages of the prior art by providing a simplified method for carrying out emulsion crystallisation with recycle of emulsion. The present invention also provides a method for obtaining substances at ultra-high purity levels and at
10 excellent yields. According to the invention, a process is provided for purifying an impure substance through emulsion crystallisation comprising the steps of (a) forming an emulsion of organic liquid droplets in a continuous water phase, which emulsion contains the impure substance; (b) super-saturating the emulsion in the substance; (c) inducing crystallisation of the substance, whereby crystallisation takes place in the water phase; (d) isolating the
15 crystals of the substance from the emulsion, yielding an emulsion-filtrate; (e) dissolving additional impure substance in the emulsion-filtrate; and (f) repeating steps (b)-(d) with the emulsion obtained from step (e).

Detailed Description of the Invention

20 Impure substances to be purified according to the present invention can be any substances that lend themselves to emulsion crystallisation processes. The starting impure substance will typically contain > 60% by weight purity of the substance, preferably >70%, more preferably > 80%. Particularly good results have been found in cases > 95% purity, which
25 have led to final purity of the substance of e.g. > 99.9%.

Emulsions and their formation are well-known in the art. Emulsions are, by definition, "droplets" dispersed in a "continuous phase". In the present invention, the droplets are organic liquid droplets and the continuous phase is a water phase.

30 The emulsion optionally contains additives such as surfactants and dispersants, known in the art, for assisting formation and stabilization of the emulsion, and for facilitating the transport of the substance out of the organic liquid droplets and into the water phase, where crystallisation takes place on a crystal surface (i.e. either the seed crystal or spontaneously
35 formed crystal). Such surfactants and dispersants will be chosen according to the nature of the emulsion, and can be nonionic, anionic and/or cationic. The additives will normally be present in an amount of 0.01-30 w/w %, preferably 0.1-20 w/w %.

The droplets typically vary in diameter from approximately 0.05 to 80 μm . Droplets with diameter in the range of 0.3 to 80 μm are known as "macrodroplets", and the emulsions as "macroemulsions". Droplets with diameter in the range of 0.05 to 0.3 μm are known as "microdroplets", and the emulsions as "microemulsions". For the sake of simplicity, the terms "droplets" and "emulsions" as used herein encompass both macro- and microdroplets and macro- and microemulsions.

The organic liquid phase of the droplet will be water insoluble. 'Water insoluble' in this context means anything less than water miscible, though in most cases the organic liquid phase will mix with water in an amount not more than 30% w/w at the temperature at which crystallisation takes place.

The emulsion may further contain a buffering agent, such as sodium acetate and acetic acid, for maintaining pH of the emulsion at a desired level, antifreezing agents and solubility adjusting agents, as is known in the art; and may also contain a solubilizer for the impure substance, such as acetone or methanol, which can be easily removed following crystallisation and re-used.

The emulsion can be super-saturated, and crystallisation induced, by any conventional means. Typically, super-saturation will be accomplished by cooling the emulsion. Crystallisation can be initiated either spontaneously, or by seeding with the seed crystals of the substance.

Formation of the original emulsion, as well as re-loading of emulsion-filtrate with impure substance, can be carried out in the vessel in which crystallisation take places, or can be carried out in a separate vessel. This separate vessel will preferably be equipped with stirring, high shear equipment and/or heating means so that an optimum emulsion can be produced.

Isolation of crystals from the emulsion can be carried out by any conventional means, such as filtration or centrifuge. Centrifuging is preferred, since it results in a higher percentage of the emulsion-filtrate being separated from the crystals.

The emulsion-filtrate obtained following isolation of crystals is then 're-loaded' with impure substance, i.e. impure substance is added to it, and dissolved. Dissolving can be carried out by any conventional means, e.g. any one or more of ultrasound, heating and stirring.

Following re-loading and dissolving of the impure substance, the emulsion-filtrate is treated like the original emulsion and is further processed as before; i.e. super-saturated in the substance, crystallisation is induced and the crystals are isolated. Recycling of emulsion-filtrate can be carried out as many times as yields acceptable results. With increasing
5 repetition of recycling of emulsion-filtrate, there is a risk that the purity of crystals isolated will decrease as the level of impurities in the emulsion builds up.

Isolated crystals of substance can be washed as known, e.g. with water, optionally containing surfactants. Applying washing water to the crystals as they are being centrifuged
10 provides a particularly convenient means for carrying out the process.

Representative examples falling within the scope of the present invention but not intended to limit the scope of the present invention follow:

15 Example 1 – Fluorene

120 g of technical grade fluorene (85% purity) are added to one liter of a micro-emulsion formed from 10% acetophenone, 50% acetone, 10% Synperonic NP 10 (a nonylphenol surfactant, ethoxylated with 10 mol ethyleneoxide; ICI PLC, England) and 30% water. Heating
20 to 95-100 °C dissolves all of the fluorene to provide a clear emulsion. Cooling to room temperature super-saturates the emulsion and yields crystals of fluorene within one hour.

The purified crystals are isolated from the emulsion by centrifuging, and the emulsion-filtrate is set aside. The crystals are washed with a total of 0.5-2 liters of water whilst being
25 centrifuged to remove excess water, and dried at 50-60°C. Alternatively to being washed in the centrifuge, the crystals may be dispersed in water, and this dispersion, then, centrifuged and dried.

The emulsion-filtrate is now re-loaded with 80 g of the same technical grade fluorene, which
30 is then heated at 95-100 °C to dissolve all of the fluorene. The resulting emulsion is treated as before, to yield purified crystals and emulsion-filtrate. This procedure is again repeated so that a total of three crystallisations are carried out. The fluorene crystals produced have a purity on the order of 95%. The total yield obtained from 1 liter emulsion following three crystallisations is 83.5%. This compares with a yield of 70.6% following a single
35 crystallisation.

Example 2 - 2,4-Dinitrophenol

140 g of 2,4-dinitrophenol (97% purity) are added to 2 liters of a solution consisting of 2% Soprophor FL (a surfactant), 2% polyvinylalcohol (m.w. 15,000), 2.5% benzonitrile and 93.5% water. The 2,4-dinitrophenol is dissolved, and the solution is emulsified by heating to 90-95 °C and applying ultrasound. Any remaining solids are filtered off. The emulsion is cooled to room temperature over a period of 16 hours, during which 2,4-dinitrophenol crystallises as rectangular plates. These crystals are filtered and washed with 0.5 liters 1% Synperonic NP 10 solution and 1 liter water. The resulting crystals have a purity of > 99.9%.

The emulsion-filtrate is re-loaded with 93.5 g of the 97% 2-4-dinitrophenol and re-emulsified. The emulsion is further treated as described in the previous paragraph. The process is then repeated a third time.

Example 3 – Anthracene

15 g of technical grade anthracene (94.5% purity) are added to 1.5 liters of a micro-emulsion formed from 10% benzonitrile, 50% N-methylpyrrolidinone, 10% Synperonic NP 10 and 30% water. Heating to 95-100 °C dissolves all of the anthracene to provide a clear emulsion. Cooling to room temperature super-saturates the emulsion and yields crystals of anthracene within two hours.

The purified crystals are isolated from the emulsion by centrifuging, and the emulsion-filtrate is set aside. The crystals are washed with a total of 0.5-2 liters of water, centrifuged a second time, and dried at 50-60°C.

The emulsion-filtrate is now re-loaded with 15 g of the same technical grade anthracene, which is then heated at 95-100 °C to dissolve all of the anthracene. The resulting emulsion is treated as before, to yield purified crystals and emulsion-filtrate. This procedure is again repeated so that a total of three crystallisations are carried out. The anthracene crystals produced have a purity on the order of 99.8 %. The total yield obtained from 1.5 liters emulsion following three crystallisations is 86.9% This compares with a yield of 82.1% following a single crystallisation.

Claims:

1. A process for purifying an impure substance through emulsion crystallisation comprising the steps of
 - (a) forming an emulsion of organic liquid droplets in a continuous water phase, which emulsion contains the impure substance;
 - (b) super-saturating the emulsion in the substance;
 - (c) inducing crystallization of the substance, whereby crystallization takes place in the water phase;
 - (d) isolating the crystals of the substance from the emulsion, yielding an emulsion-filtrate;
 - (e) dissolving additional impure substance in the emulsion-filtrate; and
 - (f) repeating steps (b)-(d) with the emulsion obtained from step (e).
2. A process according to claim 1 wherein crystals are isolated from emulsion in step (d) by centrifuge.
3. A process according to claim 1 or 2 wherein the emulsion is a micro-emulsion.
4. A process according to claim 1 or 2 wherein the emulsion is a macro-emulsion.
5. A process according to any one or more of the preceding claims wherein dissolving of additional impure substance in step (e) is carried out by any one or more of ultrasound, heating and stirring.
6. A process according to any one or more of the preceding claims wherein the crystals isolated in step (d) are washed with water optionally containing surfactant.
7. A process according to claim 6 wherein the washing water is applied to the crystals during centrifuging.
8. A process according to any of the preceding claims wherein crystallisation is induced by seeding with seed crystals of the substance.

9. A process according to any one of claims 1 to 8 wherein dissolving of additional impure substance in step () is carried out by stirring.
- 5 10. A process according to any one of claims 1 to 8 wherein dissolving of additional impure substance in step (e) is carried out by ultrasound and/or heating.

INTERNATIONAL SEARCH REPORT

Intern. Application No.

PCT/EP 00/02001

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B01D9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 32644 A (REUTER CHEMISCHE APPARATEBAU ;REUTER KARL (DE)) 12 September 1997 (1997-09-12) cited in the application	1-6,8-10
Y	page 2, line 19 -page 5, line 8 page 15, line 1 -page 17, line 22	7
Y	US 3 141 743 A (THE NORTH AMERICAN COAL CORPORATION) 21 July 1964 (1964-07-21) column 4, line 48 -column 6, line 18	7

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

8 May 2000

Date of mailing of the international search report

15/05/2000

Name and mailing address of the ISA

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Authorized officer

Persichini, C

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/EP 00/02001

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9732644	A	12-09-1997	EP	0956122 A	17-11-1999
US 3141743	A	21-07-1964	FR	1330983 A	16-12-1963
			GB	1013984 A	
			NL	280232 A	

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference PC 00 091 K	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/EP00/02001	International filing date (day/month/year) 08/03/2000	Priority date (day/month/year) 17/03/1999
International Patent Classification (IPC) or national classification and IPC B01D9/00		
Applicant REUTER CHEMISCHE APPARATEBAU KG et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.


2. This REPORT consists of a total of 4 sheets, including this cover sheet.

- ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 27/09/2000	Date of completion of this report 07.06.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Persichini, C Telephone No. +49 89 2399 8617



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/02001

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-5 as originally filed

Claims, No.:

1-10 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/02001

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	
	No:	Claims	1-6, 8-10
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-10
Industrial applicability (IA)	Yes:	Claims	1-10
	No:	Claims	

2. Citations and explanations
see separate sheet

- (1) WO-A-97 32 644
- (2) US-A-3 141 743

Re Item V

1. Document (1) discloses a process for purifying an impure substance (see (1), page 2, lines 19, 20 in context with page 3, lines 28, 29) through emulsion crystallisation (1), page 2, lines 21 to 25 in context with page 3, line 1) comprising the steps of
 - (a) forming an emulsion of organic liquid droplets in a continuous water phase, which emulsion contains the impure substance ((1), eg page 3, lines 31, 32 in context with page 5, lines 11 ff, page 5, line 4, page 9, lines 1 to 3 and page 14, lines 13 to 23);
 - (b) super-saturating the emulsion in the substance ((1), eg page 14, line 20, 21 or page 16, lines 8 to 11);
 - (c) inducing crystallization of the substance, whereby crystallization takes place in the water phase ((1), page 9, line 30 to page 10, line 4 in context with page 2, lines 27 to 29 and page 5, line 4);
 - (d) isolating the crystals of the substance from the emulsion, yielding an emulsion-filtrate ((1), eg page 14, lines 1 to 3, page 16, lines 25 to 27 or page 17, lines 6 to 17);
 - (e) dissolving additional impure substance in the emulsion-filtrate (page 16, lines 26 to 31 in context with page 15, lines 26 to 32); and
 - (f) repeating steps (b)- (d) with the emulsion obtained from step (e) ((1), page 16, line 33 to page 17, line 5)

Consequently, no difference between the subject-matter defined by claim 1 and the process disclosed in document (1) can be seen. Therefore, the subject-matter of claim 1 is not new and claim 1 does not meet the requirements of Art. 33(2) PCT.

2. In the light of documents (1) and (2) the features of the dependent claims appear to be either known or evident. Thus the dependent claims do also not meet the requirements of Art. 33(2) and (3) PCT.

ENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference PC 00 091 K	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/EP 00/ 02001	International filing date (day/month/year) 08/03/2000	(Earliest) Priority Date (day/month/year) 17/03/1999
Applicant REUTER CHEMISCHE APPARATEBAU KG et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the language, the International search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the International search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ Certain claims were found unsearchable (See Box I).

3. ☐ Unity of invention is lacking (see Box II).

4. With regard to the title,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the abstract,

☐ the text is approved as submitted by the applicant.

☒ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

☒ None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/EP 00/02001

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

A method for purifying substances through emulsion crystallisation is described, whereby (a) an emulsion of organic liquid droplets in a continuous water phase containing the impure substance is formed; (b) the emulsion is super-saturated in the substance; (c) crystallisation of the substance in the water phase is induced; (d) the crystals of the substance are isolated from the emulsion, yielding an emulsion-filtrate; (e) additional impure substance is dissolved in the emulsion-filtrate; and (f) steps (b)-(d) are repeated with the emulsion obtained from step (e).

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/EP 00/02001

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B01D9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 32644 A (REUTER CHEMISCHE APPARATEBAU ; REUTER KARL (DE)) 12 September 1997 (1997-09-12) cited in the application page 2, line 19 -page 5, line 8	1-6,8-10
Y	page 15, line 1 -page 17, line 22	7
Y	US 3 141 743 A (THE NORTH AMERICAN COAL CORPORATION) 21 July 1964 (1964-07-21) column 4, line 48 -column 6, line 18	7

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"Z" document member of the same patent family

Date of the actual completion of the international search

8 May 2000

Date of mailing of the international search report

15/05/2000

Name and mailing address of the ISA

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Fax: (+31-70) 340-3016

Authorized officer

Persichini, C

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 00/02001

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9732644	A	12-09-1997	EP	0956122 A	17-11-1999
US 3141743	A	21-07-1964	FR	1330983 A	16-12-1963
			GB	1013984 A	
			NL	280232 A	